Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 4 (2011) 5822–5829

Energy Procedia

www.elsevier.com/locate/procedia

GHGT-10

Policy instruments for advancing CCS in Dutch power generation

Heleen Groenenberg[a,c], Ad Seebregts[a], Pieter Boot[b]

a Energy research Centre of the Netherlands, P.O.Box 56890, 1040 AW, Amsterdam, The Netherlands
Corresponding author: seebregts@ecn.nl
b Ministry of Economic Affairs, The Netherlands
c Currently, Ecofys, P.O. Box 8408, 3503 RK Utrecht, H.Groenenberg@Ecofys.com, The Netherlands

Abstract

The Netherlands is heavily dependent on the success of carbon capture and storage (CCS) for its decarbonisation policy. This paper discusses several ways how CCS in the Dutch power sector can be stimulated after the round of demonstration activities up to 2015. It describes recent policy developments in the UK, US and Germany, and concludes that a policy package could be the most useful way forward if it includes a financial incentive to cover additional costs of CCS. The costs of financial support could amount to 1-3% of the Dutch electricity bill, even with CO_2 prices in the €20-50 range until 2030. A policy package could also include a regulatory instrument like an emissions performance standard (EPS) or other regulation for new coal-fired power plants to provide additional certainty. The EU Treaty explicitly leaves room for more stringent regulation from Member States required to protect the environment.

Keywords: Type your keywords here, separated by semicolons ;

1. Introduction

CO_2 capture and storage technology is anticipated to play an important role in the Dutch climate mitigation portfolio. CCS may be able to reduce emissions in the Netherlands by tens of megatons per year. A scenario might be the capture of 4-10 Mt CO_2 per year in the Netherlands by 2020 and up to 80-100 Mt in 2050 [1]. It follows that effective technology policies are required to advance the timely introduction and diffusion of CCS technologies.

This is particularly important in view of plans tabled in the last few years for the construction of five new coal plants in the Netherlands, adding up to an additional 5.5 GW and giving rise to concerns about increasing CO_2 emissions. Therefore, the ambition from the Dutch government to link up to international efforts and realize CO_2 capture and storage (CCS) technology has been substantiated.

In the Dutch Clean and Efficient program two CCS demonstrations were foreseen [2], and the Dutch government has committed to contributing financially to at least one of them. More policies were announced in the June 2009

doi:10.1016/j.egypro.2011.02.580

Policy Letter to the Dutch Lower House [3]. Policies should contribute to meeting as much as five preconditions including:

- Decrease of the costs of CO_2 capture technology
- Effective organization of CO_2 infrastructure and storage
- Sufficient legal underpinning of responsibility and liability
- Safeguarding of potential storage locations
- Adequate financial support.

Furthermore, safety and communication and public participation were named as important issues to address. The policy letter made reference to early investment subsidies for CCS demonstrations. From the European Economic Recovery Plan [3] 180 M€ was reserved for a CCS demonstration from Eon and Electrabel in the Rijnmond area. Furthermore, 300 Mt emission allowance units have been made available for twelve demonstrations of CCS or innovative renewable energy in the EU, and it is anticipated that a CCS demonstration in the Netherlands will be among those twelve.

Apart from these early investments, the Ministry of Economic Affairs announced an initial assessment of measures to stimulate CCS alongside the EU Emissions Trading Scheme (EU-ETS). In her November letter, the Minister announced 'some kind of legal obligation' to ensure that CO_2 capture and storage will be applied in the Netherlands, alongside the EU ETS [4]. Indeed, the EU ETS has been advocated widely as the prime instrument for advancing CCS. It has been designed as an instrument to reduce GHG emissions cost-effectively and as such has gained widespread support. Recently however, doubts were raised within both the public and private sector concerning the effectiveness of the EU ETS in its current form as an instrument to also induce long term technological change, because the CO_2 price level so far has been low and volatile and because a perspective on a high and stable CO_2 price is still lacking. Sceptics argue that the ubiquitous availability of low cost abatement options in EU ETS sectors against a background of low CO_2 price levels holds back investors from making early investments in immature technologies, such as CO_2 capture and storage. Indeed, with a project cost of CCS from coal-based capacity of around 48 €/tCO_2 in 2020 and a CO_2 price on the order of 30 €/tCO_2 [1], the EU ETS indeed does not provide an effective signal to invest in CCS.

Consequently, a major point of debate concerns the question how to ensure investor confidence, and which complementary policies besides the EU ETS may be applied to stimulate the implementation of CCS, in particular during its pre-commercialisation phase. Both regulation-based policies and financial instruments have been advocated to help avoid a lock-in in carbon intensive technologies. The first group includes instruments such as a CCS mandate or an emissions performance standard (EPS) at the plant level, while examples of the latter are a feed-in subsidy or tariff or a tender system. The United Kingdom and the United States are active players in the formulation of proposals for effective incentives for CCS. In these countries CCS policies combine both carrot and stick, including financial and regulatory instruments. Initial assessments of various instruments have been carried out in a number of studies [1,4,5].

This study intends to contribute to a debate on regulations and incentives in possible integrated policy package for CCS in the Netherlands. It describes possible implications of different pathways for the roll-out of CCS in the Netherlands. By means of modeling, indicative illustrations of possible outcomes will be provided. In particular, the following questions are addressed:

- What are current developments in the UK, the US and Germany regarding the introduction of complementary policies for CCS? (Section 2);
- What pathways for the roll-out of CCS in the Netherlands may be foreseen (Section 3)?
- What would these pathways imply for the export of Dutch electricity and for wholesale electricity prices (Section 4)?
- What would be the cost of financial support for CCS in the Netherlands (Section 5)?
- What restrictions does the EU legal framework pose against the introduction of complementary policies for CCS in the Netherlands (Section 6)?

The paper ends with a number of policy relevant conclusions (Section 7).

2. Policy developments in the UK, the US and Germany

Various countries have introduced policies for advancing CCS, or have an ongoing debate on the matter.

The United Kingdom is a front-runner in this respect. The UK government has started up a range of initiatives to speed up introduction and deployment of the technology. These initiatives include regulation and financial incentives. It is required to demonstrate CCS for each new coal plant on at least 300 MW of its net capacity. These demonstrations can be funded by a levy. The UK government proposed that new coal-fired power stations should be required to retrofit CCS to their full capacity within a period of five years in which CCS has been independently assessed economically and technically proven. This review will take place in 2018 and should involve a broader assessment of the status of CCS and its role in decarbonisation of the electricity mix. A final decision on specificity of the regulation for retrofitting – EPS or CCS mandate – has not been taken.

The United States introduced legislation at State level, mostly on the West coast but also in Illinois which is more dependent on coal. A generic type of regulation, such as an EPS, is preferred. Regulation will have a gradual effect, which makes it more acceptable for industries. Some states with coal interests have adopted a package approach in the expectation that this might present an economic opportunity. At federal level several approaches are being discussed, i.e. different types of cap and trade systems, but no final decision has been taken. The Environment Protection Agency (EPA) has taken the first steps towards standards based on 'best available control technology', but the details are not clear yet and long legal battles are anticipated.

Germany is hesitant about pursuing specific CCS measures for several reasons. Renewable energy and nuclear energy dominate the political agenda. The federal government has to take different regional interests, e.g. the future of coal, storage in backyards, into account.

3. Pathways for the roll-out of CCS in the Netherlands

The rate of at which CCS will be introduced in the Netherlands will depend on the development of the CO_2 price, cost reductions (notably for CO_2 capture), and incentivizing policies, apart from possible negative public perceptions. The implications of different rates of introductions for wholesale electricity prices have been analysed on the basis of five pathways for the roll-out of CCS against a reference scenario. The reference scenario is based on the new reference projection for the Dutch government [6, 6B][1] and includes both existing and newly planned energy policies. The CO_2 price is assumed 20 euro/ton until 2020, increasing to a level of 40 and 50 euro/ton in 2030 and 2040 respectively. Such CO_2 prices will not be sufficient to make CCS an economically viable option. Earlier estimates of ECN [12, 13] indicate that a CO_2 price of 60 to 90 €/ton of CO_2 would be needed for CCS in power generation in the time frame up to 2020-2025.

One of the pathways was assumed to reflect the developments of an EPS of 350 g/kWh without any financial support. It was argued and illustrated by electricity market model analyses that without any financial support such an EPS will lead to a shift to gas and to a 'de facto' immediate closure of coal-based capacity. For the other pathways it was assumed that the coverage of the financial gap by a financial incentive is sufficient to deploy carbon capture to various degrees.

In each of the pathways with financial support, assumptions have been made on the extent of CCS deployment on new coal or new gas. The amount of CCS deployed in terms of MW_e (net) is given in **Error! Reference source not found.**. For all cases, it has been assumed that:

- No CCS on old coal (built and operated before 2010) will occur.
- No CCS retrofit on old and new gas operated before 2020 will occur.
- Existing coal-fired plants will be decommissioned gradually.

[1] Details on this new reference projection and the CCS deployment schemes are given in another contribution to this Conference [7]

Table 1. CCS deployed in MW_e in Dutch power generation (net)

	2015	2020	2025	2030	Remarks
Reference projection	200	200	200	200	Only 1 demo in 2015-2020
0 **Only EPS** [1]	200	0	0	0	
1 **Slow Coal** (SC) [2]	200	980	1680	3080	Only 1 demo in 2015, All retrofit on new coal built in 2012-2015, in phases.
2 **Fast Coal** (FC) [2]	400	1680	4080	5080	2 demos in 2015, retrofit on new coal built in 2012-2015, and on additional new coal 2025-2030
3 **Slow Coal Gas** (SCG) [2]	200	980	1680	4080	Only 1 demo in 2015 All retrofit on new coal built in 2012-2015, in phases. CCS on 1000 MW new gas in 2030
4 **Fast Coal Gas** (FCG) [2]	400	1680	5080	7080	2 demos in 2015, retrofit on new coal built in 2012-2015, and on additional new coal 2025-2030 CCS on 1000 MW new gas in 2025, and on new 2000 MW gas in 2030

[1] Environmental Performance Standard (EPS) of 350 g/kWh; no financial support
[2] Assuming sufficient financial support is available. The 350 gram/kWh is not necessarily met for all cases. The various pathways consider the context and 'realism' of the original reference projection. Energy penalties reduce for plants that deploy CCS later on.

If the demonstration activities have proven CCS to be reliable (technically and the energy penalty has decreased), if other crucial aspects have been solved (safety and other aspects of transport and storage) and if CCS has proved to be socially acceptable – if all these conditions have been met, the introduction of CCS is mainly a financial issue. Still, there may be good reason to introduce some form of regulation in the form of a CCS mandate or an emissions performance standard. Not only has the Dutch government already announced that it would introduce some kind of legal obligation. This would provide a stronger legitimation for CCS investment decisions in board rooms and thus create more certainty.

4. Implications for the wholesale market price of electricity and export

For electricity prices and export effects 5-year averages have been given in Table 1 below. In the 'Only EPS' case, i.e. without any additional national financial support, the wholesale market electricity prices increase by about 10% compared to the reference scenario. This will also have an increasing effect on end user prices in the Netherlands. There is hardly any noticeable effect for the four pathways with the financial support to compensate for the higher costs. The changes in the merit order appear to be negligible as to the impact on the wholesale electricity prices. The main reason is that new coal with CCS will have variable costs of production substantially lower than the average wholesale electricity market prices.The main reason is the lower CO_2 costs and despite of the higher coal cost (energy penalty) and less net electricity production.

Table 1 *Average wholesale market electricity price, the Netherlands*[1]

[€/MWh]	2015	2020	2025
Reference	58.8	60.5	63.3
0 Only EPS	58.8	64.5 [1]	70.0
1 SC	58.8	60.4	63.6
2 FC	58.8	60.7	63.4
3 SCG	58.8	60.4	64.0
4 FCG	58.8	60.7	63.4

[1] For electricity prices effects, the 5-year averages around the indicated 'midpoint' year have been given.

Following this price increase, the net export volume decreases considerably over the reference scenario (Table 2). This extreme case worsens the competitive position of the Dutch power production. There is hardly any noticeable effect for the four pathways with financial support. In the period 2015 to 2030, small increases of no more than 1.5 TWh are observed. The reason for the small differences is the assumption that producers are compensated for the higher cost in the case of CCS deployment. Note that during the years 2000-2008, the Netherlands was a net importer of electricity (between 15-20 TWh on a yearly basis).

Table 2 *Net export from NL to neighbouring countries, in TWh* [1]

	2015	2020	2025
Reference	15.6	15.2	24.7
0 Only EPS	15.6	9.3	12.6
1 SC	16.2	16.7	25.1
2 FC	16.4	16.4	24.8
3 SCG	16.2	16.7	25.1
4 FCG	16.4	16.4	24.9

[1] For export effects, the 5-year averages around the indicated 'midpoint' year have been given.

To sum up, without any national financial support, the wholesale market electricity prices increases by about 10 per cent. As a result end user prices in the Netherlands will also increase. Without financial support to CCS the net export will decrease considerably. Instead of some 15 TWh (2020) to 25 TWh (2025), it could amount to half of that, i.e. 9 to 13 TWh. In a policy package with financial support the price will not increase and exports will not decrease – effectively the financial support only drives this result.

5. Cost of policies

The introduction of CCS comes at a cost, most likely to be covered by both industry and government. In order to estimate the magnitude of the total cost, it is insightful to calculate the financial gap. Assuming a cost of electricity production by coal with CCS of 78 €/MWh, and an average wholesale market electricity price of about 61 €/MWh (with 20 €/ton $CO_{2)}$, the financial gap would be 17 €/MWh. With 20% co-firing of biomass, the gap would be 23 €/MWh Table 3 shows the magnitude of the financial gap for different production cost levels and wholesale market prices, for coal with CCS in the Slow Coal pathway, both without biomass and with 20% cofiring. The results indicate that CCS becomes economically viable for CO_2 prices between 70 and 80 €/ton CO_2 (in the context of the reference scenario).

Table 3 *Financial gap for coal with CCS, with different CO_2 prices, in the Slow Coal pathway (indicative and for illustration only)*

Cost of electricity[€/MWh]		Wholesale market price (avg) [€/MWh]	Financial gap [€/MWh]		CO_2 price [€/ton]
100% coal with CCS	*80% coal, 20% biomass with CCS*		*100% coal with CCS*	*80% coal, 20% biomass with CCS*	
78 (default)	84	61	17	23	20
81	82	71	10	21	50
82	81	76	8	5	60
83	80	81	2	- 1	70
84	79	86	- 2	- 7	80

Table 4 *Total 'electricity bill' based on wholesale market prices*

	2020	2025	2030
TWh, total demand	128.3	128.7	131.0
average price, €/MWh	61	63	67
Total, M€	7763	8140	8838

The cumulative financial gap can be compared to the overall 'electricity bill' based on domestic electricity demand and the average wholesale electricity price. This total electricity bill ranges from almost 8 billion € in 2020 to 9 billion € in 2030 in the reference scenario (Table 4), while electricity produced in coal-fired plants with CCS in the 'Slow Coal& Gas pathway increases threefold between 2020 and 2030. The cumulative financial gap related to these production levels is only a few percent of the total electricity bill (Table 5).

Table 5 *Cumulative financial gap for coal with CCS in the Slow Coal & Gas pathway (100% coal, so no biomass co-firing)*

Electricity from coal+ CCS	2020 *6.0 TWh*	2025 *9.2 TWh*	2030 *18.0 TWh*	2020 *6.0 TWh*	2025 *9.2 TWh*	2030 *18.0 TWh*
CO_2 price [€/t CO_2]	Cumulative financial gap [M€/yr]			% of total ' electricity bill'		
20	103	157	305	1.3%	1.9%	3.5%
50	60	92	180	0.8%	1.1%	2.0%
60	48	74	144	0.6%	0.9%	1.6%
70	12	18	36	0.2%	0.2%	0.4%
80	- 12	- 18	- 36	- 0.2%	- 0.2%	- 0.4%

6. Comparison of financial instruments

Various policy instruments may be used to fill the financial gap, including feed-in tariffs or premiums, a contract for difference, or a tender system. Stimulating CCS in the Netherlands with a feed-in scheme, notably when based on an (additional) premium, has the advantage that the instrument could be linked to the existing scheme for renewable energy, the Stimulering Duurzame Energie (SDE). In the medium term, feed-in premiums may therefore be the preferred instrument for reducing the financial risk of a CCS operation. On the downside, it requires processing possibly biased cost information from industry by the state, it involves the risk of excessive profits should CO_2 and fossil fuel prices be lower respectively higher than anticipated, and it may render the energy sector dependent on subsidies.

A contract for difference on the contrary will not require evaluation by the state of possibly underestimated cost information. It would however require the introduction of an entirely new policy instrument, which possibly will involve higher transaction costs and most likely give rise to questions as to why a dedicated instrument would be required for CCS and not for other abatement technologies.

A tender system has an intermediate position. It is being used widely in Dutch energy policy, and competition will discourage project developers to overestimate costs. It will involve a minor risk of windfall profits in case fossil fuel prices are lower than anticipated, and require efforts from a state agency to evaluate the project.

However, the three new coal-fired power plants that will be addressed by a financial instrument are technically comparable and therefore the costs will not differ much. Hence, an approach that is comparable with the SDE system for renewable energy (feed-in premium) might be an alternative for a tender system at this stage already. In any case, it seems wise to look at a simple approach for these three coal-fired power plants. More sophisticated approaches could be considered for next steps, also taking into account the learning experiences of other countries.

7. Restrictions of the EU legal framework

The EU Treaty leaves room for national measures on top of EU policies that would be required to protect the environment. It will therefore probably not constitute an obstacle for national CCS policies. Most likely, the UK government will want to refer to this article in the Treaty should UK regulatory policy be challenged from a legal perspective. This will most probably be done as the IPPC Directive has been codified in January 2008 in which a relevant article states: *"Where emissions of a greenhouse gas from an installation are specified in Annex I to Directive 2003/87/EC […] the permit shall not include an emission limit value for direct emissions of that gas unless it is necessary to ensure that no significant local pollution is caused."*. A proposal by the European Commission for a Directive on industrial emissions contains similar language. This seems to exclude the possibility of introducing an EPS. However, at the same time the Directive for Geological Storage of CO_2 explicitly opens a perspective on an EU wide emissions performance standard by 2015.

All in all, the legal situation is uncertain. The EU Treaty leaves room for national laws that are stricter than the European standard. One Directive mentions an EPS explicitly, but another one prohibits including CO_2 in permits. Thus, it could be argued that a case for a stricter national approach can be made. A situation in which a financial package fully or partially compensates for the cost differential with unabated fossil fuel has to be accepted by the European Commission, but again a case can be made.

8. Concluding remarks

In this paper the implications of different pathways for advancing CCS in the Netherlands were discussed, enabled by financial and possibly regulatory policies. Financial instruments may include a financial gap policy, a tender system, or a contract for difference, while a regulatory instrument could be an emissions performance standard or a CCS mandate. Without any financial support regulatory instruments are likely to enforce a shift to natural gas or a higher share of biomass co-firing, rather than advancing CCS. Financial support on the contrary will help to spark off investments in CCS. It will compensate for the difference between the costs of electricity from unabated coal and electricity from coal and CCS, without giving rise to an increase of the wholesale electricity price.

Obviously, financial support will have budgetary implications, also when it is relatively modest. Indicatively, it could be comparable to 1 to 3 per cent of the total wholesale electricity bill, even if CO_2 prices remain in the € 20-50 range in the period 2020-2030. Based upon assumptions in this paper, the cumulative financial gap would be in the range of € 100 million in 2020 (with a CO_2 price of €20 and 6 TWh) to € 180 million in 2030 (18 TWh, with a CO_2 price of €50). With other fuel and CO_2 prices, and other levels of CCS deployment these amounts would be different. These costs could be financed either from a share of the auction revenue of CO_2 allowances paid by electricity generators and/or a small levy on the electricity price, either on the wholesale price or on end user prices.

If the government wants to give a clear indication about its vision on the future of electricity production and decarbonisation a package it may prefer to include regulation as well. Regulatory instruments alongside financial support may provide more certainty on the long-term character of CCS policies. A CCS mandate may be a better guarantee that investments are directed towards CCS but it is difficult to imagine a CCS mandate when this technology is still in the demonstration phase. An Emissions Performance Standard (EPS) would allow greater flexibility, and may initially be on the order of 350 g/kWh. A lower standard might be difficult to defend, since in that case coal plants would need to be even cleaner than modern gas-fired plants. Although the IPPC Directive forbids an emission limit for direct emissions from greenhouse gases, the EU Treaty explicitly leaves room for stricter regulations by Member States that would be required to protect the environment.

Policies stimulating CCS will only influence the overall CO2 emission if they are combined with a reduction of the EU-ETS cap. Theoretically, strong arguments can be made against a combination of the existing ETS cap on the one hand and regulation on the other [8]. If the ETS cap is not adjusted, an EPS next to the EU ETS will not further reduce greenhouse gas emissions covered by the trading scheme, since emissions are set by the cap. Moreover, an EPS may reduce the demand for emission allowances and, hence, lowers the price for these allowances. Thus, the incentive for all other installations not covered by the regulation may be reduced. To counter this effect, the cap has to be decreased in combination with the regulation.

Any policy package for CCS in the Netherlands, whether or not including regulation alongside financial support, would need to be evaluated timely, e.g. by 2018. This would be after the review by the European Commission of the Storage Directive, and would allow for taking experience with the first CCS demonstrations. At that moment the prospects of CCS in gas-fired power stations and an eventual stricter EPS for coal-fired power stations at a later moment could be considered as well. Thus, a successful roll-out of CCS on the longer term may be ensured.

Acknowledgement

The European Climate Foundation is acknowledge for sponsoring this study. Herman Snoep (ECN) and Ron Wit (Stichting Natuur & Milieu) are thanked for their valuable comments on the full report. The responsibility of this paper lies with the authors.

References

[1] McKinsey. Large scale roll out scenarios for CCS in the Netherlands: 2020-2050. Final report for the Ministry of Economic Affairs and the Ministry of Housing, Spatial Planning and the Environment. Amsterdam; October 2009.
[2] Ministry of Housing, Spatial Planning and the Environment. Working program Clean and Efficient. The Hague; September 2007.
[3] Ministry of Economic Affairs. Beleidsbrief CCS. The Hague; 23 June 2009.
[4] European Commission. Memo 09/542, List of 15 energy projects for European economic recovery. Brussels, 9 December 2009.
[5] Ministry of Economic Affairs and Ministry of Housing, Spatial Planning and the Environment. Letter to the Chair of the Lower House. CCS in the Netherlands: decisions for the short, middle and long term. Dutch Lower House, 31209 no. 103, 18 november 2009.
[6] Groenenberg, H, de Coninck, HC. Effective EU and Member State policies for stimulating CCS. International Journal of Greenhouse Gas Control 2008; 2:653-664.
[7] Seebregts, Ad, J van Deurzen. Carbon Capture & Storage in power generation and wind energy: flexibility and reliability issues in scenarios for Northwest Europe, Paper and oral presentation for GHGT-10 Conference, 19-23 September 2010, Amsterdam.
[8] Working Group 'Schoon Fossiel'. Setting the incentives right for timely CCS deployment. Utrecht: SenterNovem; 2007.
[9] ECN/PBL.Reference Projections 2010-2020 (In Dutch). ECN report ECN-E-10- Petten/Bilthoven; 2010.
[10] Boot, PA, van Bree, B.A zero-carbon European power system in 2050: proposals for a policy package. Petten: ECN; 2010. ; Report ECN-E-10-041, April 2010. Downloadable at: http://www.ecn.nl/docs/library/report/2010/e10041.pdf
[11] Groenenberg, H, A Seebregts, P Boot. . Policy instruments for advancing CCS in Dutch power generation, ECN-E-10-032 (to be published October 2010).
[12] Seebregts, Ad, Heleen Groenenberg. How may CCS technology affect the electricity market in North-Western Europe? In: Energy Procedia 1, 4181-4191, 2009 .
[13] ECN/PBL. Verkenning Schoon en Zuinig, ECN and PBL, Petten/Bilthoven, The Netherlands, ECN-E-09-022, April 2009.